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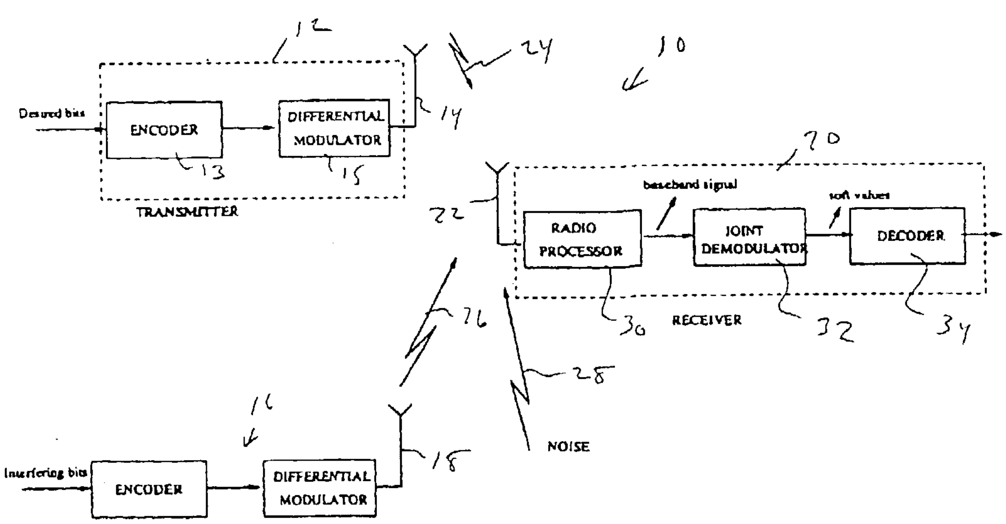

(57) Abstract: A method and apparatus generated soft values from a co-channel differentially encoded received signals. The soft values are generated by determining jointly detected symbols and corresponding joint metrics. A first potential nondetected metric sum is determined by flipping the current desired coherent detected symbol and keeping the interfered coherent detected symbol as is. A second potential nondetected metric sum is determined by flipping the previous desired coherent detected symbol and keeping the interfered coherent detected symbol as is. A minimum between the difference of the detected jont metrics and the two nondetected joint metrics is found. The soft values are then established based on the minimum difference metric.

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METHOD AND APPARATUS FOR SOFT INFORMATION GENERATION IN JOINT DEMODULATION OF CO-CHANNEL SIGNALS

BACKGROUND OF THE INVENTION

The present invention is directed toward wireless communications systems, and, more particularly, to an apparatus and method for soft information generation in joint demodulation of co-channel signals.

The performance of receivers in wireless communications systems, such as mobile communications systems, may degrade severely due to multipath fading. Although anti-fading techniques, such as antenna diversity, equalization and adaptive ray processing, are effective in improving the performance of the receiver, forward error correction (FEC) techniques may be necessary to achieve acceptable voice and data transmission in wireless communications systems. FEC techniques provide redundancy by adding extra bits to the actual information bits, which allows the decoder to detect and correct errors. To optimize decoder performance, it is important to provide accurate soft information from the demodulation process. The availability of soft information, after the demodulator, increases the performance of the concatenated (demodulator and decoder) structure considerably when compared to the use of hard information.

The generation of soft information has been used extensively in conventional single user demodulators. Several approaches for developing soft information in single user demodulators, such as soft information for maximum likelihood sequence estimation (MLSE) detection for inter symbol interference (ISI) channels, have been presented. These techniques

have been extended to $\pi/4$ shifted-DQPSK (differential quadrature phase shift keying) systems.

In code-division multiple access (CDMA) systems multiuser demodulation has gained attention. Multiuser demodulation has only recently been adopted in narrow band time-division multiple access (TDMA) base systems. Soft information generation for multiuser demodulation in CDMA is discussed in S. Verdu, "Multiuser Detection", Cambridge University Press, 1998. However, multiuser demodulation in TDMA is different from CDMA. Moreover, soft information generation for $\pi/4$-DQPSK is different from soft information generation for BPSK (bit phase shift keying) and QPSK.

SUMMARY OF THE INVENTION

The present invention relates to a method and apparatus for soft information generation in joint demodulation of co-channel signals, particularly $\pi/4$-DQPSK co-channel signals.

Particularly, the method and apparatus determines jointly detected symbols and corresponding joint metrics. A first potential nondetected metric sum is determined by flipping the current desired coherent detected symbol and keeping the interfered coherent detected symbol as is. A second potential nondetected metric sum is determined by flipping the previous desired coherent detected symbol and keeping the interfered coherent detected symbol as is. A minimum between the difference of the detected joint metrics and the two

nondetected joint metrics is found. The soft values are then established based on the minimum difference metric.

Further features and advantages of the invention will be apparent from the specification and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a mobile communication system using the method and apparatus in accordance with the invention;

Fig. 2 is a block diagram of the joint demodulator of Fig. 1 for a first embodiment of the invention;

Fig. 3 is a block diagram of the joint demodulator of Fig. 1 for a second embodiment of the invention;

Fig. 4 is a flow diagram illustrating a program implemented in the joint demodulator of Fig. 1;

Fig. 5 is a trellis diagram illustrating soft information generation for joint demodulation for flat fading channels in accordance with one aspect of the invention;

Fig. 6 is a trellis diagram illustrating soft information generation for joint demodulation for a dispersive channel in accordance with a first aspect of the invention;

Fig. 7 is a trellis diagram illustrating soft information generation for joint demodulation for dispersive channels in accordance with a second aspect of the invention;

Fig. 8 is a trellis diagram illustrating soft information generation for joint demodulation for dispersive channels in accordance with a third aspect of the invention; and

Fig. 9 is a trellis diagram illustrating soft information generation for joint demodulation for a dispersive channel in accordance with a fourth aspect of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 is a block diagram of a typical mobile communication system 10, such as IS-136, using $\pi/4$ shifted-DQPSK (differential quadrature phase shift keying). The mobile communication system 10 includes a first transmitter 12 having a first transmit antenna 14. A second transmitter 16 has a second transmit antenna 18. A receiver 20 includes a receiver antenna 22. For simplicity, only two transmitters and one receiver are shown in Fig. 1. However, the proposed invention can be applied to more than two transmitters and a receiver. In the illustrated embodiment of the invention, the receiver 20 is described as the receiver of a mobile terminal while the transmitters 12 and 16 are associated with respective base stations as part of fixed terminals, as is known. Alternatively, the receiver 20 could be the receiver in a base station, while the transmitters 12 and 16 could be the transmitters in mobile terminals, or any combination thereof.

The present invention is described herein in the context of a mobile terminal. As used herein, the term "mobile terminal" may include a mobile communications radio telephone with or without a multi-line display; a personal communications system (PCS) terminal that may combine a mobile communications radio telephone with data processing,

facsimile and data communications capability; a PDA that can include a radio telephone, pager, Internet-Intranet access, Web browser, organizer, calendar and/or a global positioning system (GPS) receiver; and a conventional laptop and/or Palm® top receiver or other appliance that includes a radio telephone transceiver. Mobile terminals may also be referred to as "pervasive computing" devices.

Each transmitter 12 and 16 includes an encoder 13 and a differential modulator 15. Information bits are encoded in the encoder 13 and the differential modulator 15 modulates theses encoded bits using $\pi/4$ shifted-DQPSK.

The invention is described under the assumption that the first transmitter 12 transmits desired information signals, and the other transmitters, such as the transmitter 16, transmit interfering signals, also referred to "interferers". The receiver 20 attempts to receive the desired user information signals correctly under the presence of the interferers and thermal noise, represented at 28. Both transmitted signals reach the receiver 20 after passing through independent propagation mediums (e. g., mobile radio channels represented at 24 and 26). The transmitted signals plus the noise 28 are received at the receiver antenna 22. While a single receiver antenna 22 is shown, the receiver 20 could have more than one antenna. The received signal is processed by a radio processor 30 which amplifies, mixes, filters, samples and quantizes the received signal to produce a baseband signal. The baseband signal is supplied to a joint demodulator 32 in accordance with the invention. The joint demodulator produces soft values which are supplied to a decoder 34. As mentioned above, channel encoding is frequently used in transmitters to provide redundancy by adding extra

bits to the actual information bits. In the receiver 20, the decoder 34 is used to decode the encoded bits while detecting and correcting possible errors in the received signal.

While a specific receiver block diagram is provided herein for the purpose of illustration, those skilled in the art will appreciate that other known architectures may also be used. Additional blocks, such as interleaving, and the like, are not mentioned herein for purposes of simplicity.

In accordance with the invention, a method and apparatus generates soft information in joint demodulation of co-channel signals. Particularly, soft information values are generated from signal samples of differentially encoded signals by demodulating both desired and interfering signals together. However, soft information values are generated for only the desired signal.

Referring to Fig. 2, a block diagram of the joint demodulator 32 of Fig. 1, in which soft information generation in joint demodulation of co-channel signals can be applied, is illustrated. The baseband received signal is applied to a likelihood information generator 36 and to a channel estimator 38. An output of the channel estimator 38 is also applied to the likelihood information generator 36. The output of the likelihood information generator 36 is applied to a likelihood information processor 40. The likelihood information processor 40 develops the soft values supplied to the decoder 34 of Fig. 1.

The channel estimator 38 estimates amplitude and phase information corresponding to the mobile radio channels for both the desired and interfering signals. The baseband received signal and the parameter estimates are used in the likelihood information

generator 36 to calculate the likelihood functions corresponding to different QPSK symbol hypotheses corresponding to the desired and interfering signals. The likelihood information generator 36 could provide likelihood or log-likelihood functions depending upon the user's preference. The likelihood information processor 40 calculates the soft information values corresponding to each bit. The partition of the functions described herein for the likelihood information generator 36 and the likelihood information processor 40 can be different depending upon user preference. Also, these two blocks can be combined to obtain a single block which generates soft information using the channel parameters and the received baseband signal.

Fig. 3 illustrates an alternative joint demodulator 32′ where the baseband received signal and parameter estimates from the channel estimator 38 are used to obtain joint metric values. These are done using a joint metric computer 36′ and a metric processor 40′. The metric processor 40′ generates soft information values corresponding to the desired signal.

As described herein, the soft information generation can be applied to both non-dispersive channels, i. e., flat-fading channels, and dispersive channels. For the $\pi/4$-DQPSK modulation using IS-136, the user bit information is contained in the differentially modulated symbols, but both the conventional equalizer and the joint demodulator use coherent symbols in the MLSE/DFSE. In the conventional equalizer, the four hypothesized states correspond to the second of two coherent symbols, i.e., the delayed coherent symbol. This results in sixteen different branch metrics that are calculated for each new received

sample. Calculating the optimal soft value for each detected bit requires estimation of the probability of that bit, which, in turn, requires the exponentiation and summation of the metric values associated with that bit. As this is computationally expensive, sub-optimal approaches using only the dominant terms from this calculation are employed. Limiting operations, such as max() or min(), are used instead of the exp() operation. Even though these approaches are sub-optimal, they reliably estimate soft bit values for use in soft-input decoding.

Although joint demodulation demodulates both desired and interfering signals together, soft information is calculated for only the desired signal. For optimal processing, the interferers bit probabilities must be integrated out of the probability of the desired signals soft bit estimate, requiring exponentiation and summation operations, that are to advantageously be avoided. Consequently, there are various different assumptions that can be made which lead to different sub-optimal approaches, described below.

For joint demodulation involving two users for a flat fading channel, the number of possible metric values at each stage is 16 because QPSK has four possibilities for each user and for two users the number of possibilities is 4*4=16. Therefore, the number of possible metric pairs for the current and previous stage is 256; i.e., 16*16=256. Among these 256 metric pairs, 128 will provide a +1 bit value for the desired differential bit, and the other 128 will provide a -1 bit value. One solution is to calculate all the metric pair sums for the detected and nondetected differential bit values, then find the minimum values among them, and then find the difference of these minimum values to calculate soft information.

However, calculation of all the metric pair sums and finding the minimum among them is highly complex. For the nondetected bit, certain assumptions can be made in accordance with the invention using various approaches.

A first such approach for a non-dispersive channel is illustrated in Fig. 5. The detected bit and corresponding coherent symbol metric pair are found for the detected bit. In Fig. 5 the detected coherent symbols are D2 and I2 at stage n and D3 and I2 at stage n-1. (The symbols having the prefix D represent the desired bit, while the symbols having the prefix I represent the interfering bit. Each symbol value corresponds to a pair of differential bits. For the nondetected bit, the coherent desired and interfering symbol values are kept as is at the current stage n, i. e., use the detected branch's metric for the current stage D2 and I2, and flip the coherent desired symbol value of the previous stage n-1 with the closest symbol that provides the nondetected bit value, while keeping the interferer as detected. This uses the symbol D4 and I2 in the example. Similarly, the coherent desired and interfering symbols are kept as is at the previous stage, i. e., use the detected branch's metric for the previous stage, D3 and I2, and flip the coherent desired symbol value of the current stage with the closest symbol that provides a nondetected bit value, while keeping the interferer as detected. This uses the symbol D1 and I2 in the example. Then, find the minimum metric pair sums corresponding to these two symbol pairs as the dominant term for the nondetected bit.

For detected coherent desired symbol values, it may not be obvious how to find a closest nondetected value. Because of the interaction between the desired and

interfering signals in the minimum metric calculation, there may be situations where the flipped desired symbol requires flipping the interfering symbol as well. It is possible to flip the desired coherent symbol value of the current or previous stage to the closest symbol value that provides the nondetected bit, while allowing the interferer coherent symbol value to float, i. e., take any value. For one interferer, this requires finding the minimum of 8 metric pair sums instead of a minimum of 2 metric pair sums.

This latter method can be extended further by also considering the other flipped (farther) coherent desired symbol and the minimum metric pair sum calculation for the nondetected bit value. In other words, the closer and farther possible coherent sum symbols are considered in flipping the detected coherent symbol. This assumes the minimum metric pair includes one of the minimum metric values of the current or previous states. In other words, the minimum of the current stage is fixed as is and it is necessary to find the minimum metric value from the previous stage that provides a nondetected bit value. In the same way, the minimum of the previous stage is fixed as is and it is necessary to find the minimum metric value from the current stage that provides a nondetected bit value. The minimum of these two possible pair sums is used as the dominant term for the nondetected bit. This approach requires finding the minimum of 16 metric pairs for the dominant term for the nondetected bit.

Unlike flat-fading channels, where the metric pairs (branch metric pairs) are used for soft information generation, the path metrics (accumulated metrics) are used for soft information generation with dispersive channels.

In accordance with the invention the difference of the surviving path and two possible nondetected paths ("SOFT POS and SOFT NEG") are calculated for each state. The nondetected paths are obtained by flipping the coherent detected symbols with the other border symbols while keeping the interferer symbol as is. Once the SOFT POS and SOFT NEG values are obtained for each state the soft bit values are calculated using these values.

A first approach for dispersive channels is shown in Fig. 6, which extends the approach of Fig. 5 to dispersive channels. For each state the difference of the surviving path and the two possible nondetected paths are calculated (SOFT POS and SOFT NEG). The nondetected paths are obtained by flipping the coherent detected symbol with the border symbols while keeping the interfering symbol as is. Assuming that the detected path is as shown in Fig. 6, and for a specific bit the nondetected paths are shown by the dashed lines, the soft information for the desired differential bit can be calculated similarly as

$$\min\left(abs(CM(n) - CMy(n)), abs\left(CM(n+1) - CMx(n+1)\right)\right)$$

Fig. 4 is a flow diagram of a routine implemented in the joint demodulator 32, see Fig. 1, illustrating this approach. The approach begins at a block 50 which determines the jointly detected symbols and corresponding joint metrics. In equalizers, the detected path metric is found. At a block 52 a first potential nondetected metric sum is determined. This is done by flipping the current desired coherent detected symbol and keeping the interferer coherent detected symbol as is. Both desired and interfering previous coherent symbols are

fixed. In equalizers, a first nondetected path metric is found at this block. At a block 54 a second potential nondetected metric sum is determined by flipping the previous desired coherent detected symbol and keeping the interferer detected symbol as is. Both desired and interfering current coherent symbols are fixed. In equalizers, a second nondetected path metric is found at the block 54. At a block 56 the difference of the detected joint metric and the two nondetected joint metrics is found. Subsequently, the minimum of these two different metrics is found. In equalizers, the difference between the detected path metric and two nondetected path metrics is found and then the minimum of these two different metrics is found. At a block 58 the soft values are generated in the conventional manner based upon the minimum difference metric.

An extension of the approach described above relative to Fig. 6 narrows down the approximation such that the desired flipped symbol allows change of the interferer symbol. As a result, all of the interfering symbols are searched to give a minimum nondetected path corresponding to a flipped coherent desired symbol. This is illustrated in Fig. 7. In short, the procedure flips the desired detected coherent symbol with the border symbol and for that specific flipped desired coherent symbol searches for all interferer symbols that provide the minimum metric value.

It is possible to narrow down the approximation further by flipping the coherent symbol not only to the closest possible symbol that provides a nondetected bit but also to other possible farther symbols. This is illustrated in Fig. 8. In this case, for each state it is necessary to store 3 different values, soft X, soft Y and soft Z. The first two difference

values are the same as in the approach of Fig. 7. The extra third difference value is obtained from the farther flipped symbol.

Narrowing down the approximation even further provides a solution as illustrated in Fig. 9. In the other approaches when the flipped path is calculated corresponding to the stage n, the assumption was made that at stage n-1 both the detected and nondetected paths were merging. Assuming that the coherent symbol at stage n-1 is fixed, then to guarantee that the flipped symbol at stage n comes from the fixed symbol at stage n-1, it is necessary to recalculate the path metric by forcing it to come from the fixed symbol's path.

All of the described methods are an approximation to the dual-min (min/min) implementation of soft information generation. Alternatively, approaches such as semi-MAP (Max *a posteriori*) based algorithms could improve performance over dual-min based approaches. In the semi-MAP based approach soft information is calculated per stage instead of calculating soft information per state. If the soft values are not connected to any specific state, there is no decision window and no path memory.

At the stage n+1, all the possible combinations of path metrics that provide a detected bit value are calculated for all branches of all states. In the same way, all the possible combinations of path metrics that provide a nondetected bit value are calculated for all branches. The minimum path metric corresponding to the detected and nondetected bit values are obtained. Soft information is calculated by finding the difference of these minimum path metrics. Since there is no decision delay, the hard decisions degrade

significantly. As a solution, the hard decisions can be calculated as usual, if the sign of the soft decision and hard decision conflict, then the value of the soft information is set to a very small number that has the sign of the hard decision. Another possible solution is to find soft information for all of the states corresponding to a desired symbol, for all the possible interfering symbol states and one desired symbol state. Therefore, there will be four soft information values at each stage, i.e., one soft information value for four states.

The present invention has been described with respect to flowcharts and block diagrams. It will be understood that each block of the flowchart and block diagrams can be implemented by computer program instructions. These program instructions may be provided to a processor to produce a machine, such that the instructions which execute on the processor create means for implementing the functions specified in the blocks. The computer program instructions may be executed by a processor to cause a series of operational steps to be performed by the processor to produce a computer implemented process such that the instructions which execute on the processor provide steps for implementing the functions specified in the blocks. Accordingly, the illustrations support combinations of means for performing a specified function and combinations of steps for performing the specified functions. It will also be understood that each block and combination of blocks can be implemented by special purpose hardware-based systems which perform the specified functions or steps, or combinations of special purpose hardware and computer instructions.

CLAIMS

WE CLAIM:

1. A method of generating soft information from co-channel differentially encoded received signals comprising:

determining jointly detected symbols and a corresponding detected joint metric;

determining a first potential nondetected metric sum;

determining a second potential nondetected metric sum;

calculating differences between the detected joint metric and the first and second potential nondetected metric sums to produce two difference metrics;

calculating a minimum of the two difference metrics; and

determining soft information values associated with the minimum of the two difference metrics.

2. The method of claim 1 wherein determining a first potential nondetected metric sum comprises flipping a current desired detected symbol and keeping a previous interfering detected symbol and determining a second potential nondetected metric sum comprises flipping a previous desired detected symbol and keeping a previous interfering detected symbol.

3. The method of claim 2 wherein flipping a current desired detected symbol and flipping a previous desired detected symbol comprise selecting a closest desired nondetected symbol.

4. The method of claim 1 wherein determining a first potential nondetected metric sum comprises flipping a current desired detected symbol and permitting a previous interfering detected symbol to float and determining a second potential nondetected metric sum comprises flipping a previous desired detected symbol and permitting a previous interfering detected symbol to float.

5. The method of claim 1 wherein flipping a current desired detected symbol and flipping a previous desired detected symbol comprise selecting a closest desired nondetected symbol and selecting a farthest desired nondetected symbol.

6. A method of generating soft information from co-channel differentially encoded received signals comprising:

determining jointly detected symbols and a corresponding detected path metric;

determining a first potential nondetected path metric;

determining a second potential nondetected path metric;

calculating differences between the detected path metric and the first and second potential nondetected path metric to produce two difference metrics;

calculating a minimum of the two difference metrics; and

determining soft information values associated with the minimum of the two difference metrics.

7. The method of claim 6 wherein determining a first potential nondetected path metric and a second potential nondetected path metric comprises flipping desired detected symbols for current and previous states with border symbols and keeping interfering detected symbols.

8. The method of claim 6 wherein determining a first potential nondetected path metric and a second potential nondetected path metric comprises flipping desired detected symbols for current and previous states with border symbols and permitting interfering detected symbols to float.

9. The method of claim 8 wherein determining a first potential nondetected path metric and a second potential nondetected path metric comprises recalculating the nondetected path metrics by forcing the nondetected path metrics to come from a fixed symbols path.

10. The method of claim 6 wherein determining a first potential nondetected path metric and a second potential nondetected path metric comprises flipping desired detected symbols for current and previous states with border symbols and farther symbols and permitting interfering detected symbols to float.

11. A receiver generating soft information from co-channel differentially encoded received signals comprising:

a joint demodulator receiving a baseband signal and comprising a likelihood information generator operable to determine jointly detected symbols and a corresponding detected joint metric, determine a first potential nondetected metric sum, determine a second potential nondetected metric sum, calculate differences between the detected joint metric and the first and second potential nondetected metric sums to produce two difference metrics, and determine a minimum of the two difference metrics, and a likelihood information processor determining soft information values associated with the minimum of the two difference metrics.

12. The receiver of claim 11 wherein the likelihood information generator determines the first potential nondetected metric sum by flipping a current desired detected symbol and keeping a previous interfering detected symbol and determines the second potential nondetected metric sum by flipping a previous desired detected symbol and keeping a previous interfering detected symbol.

13. The receiver of claim 12 wherein flipping a current desired detected symbol and flipping a previous desired detected symbol comprise selecting a closest desired nondetected symbol.

14. The receiver of claim 11 wherein the likelihood information generator determines the first potential nondetected metric sum by flipping a current desired detected symbol and permitting a current interfering detected symbol to float and determines the second potential nondetected metric sum by flipping a previous desired detected symbol and permitting a previous interfering detected symbol to float.

15. The receiver of claim 11 wherein flipping a current desired detected symbol and flipping a previous desired detected symbol comprise selecting a closest desired nondetected symbol and selecting a farthest desired nondetected symbol.

16. A receiver generating soft information from co-channel differentially encoded received signals comprising:

a joint demodulator receiving a baseband signal and comprising a joint metric generator operable to determine jointly detected symbols and a corresponding detected joint path metric, determine a first potential nondetected path metric, determine a second potential nondetected path metric, calculate differences between the detected joint path metric and the first and second potential nondetected path metrics to produce two difference metrics, and determine a minimum of the two difference metrics, and a metric processor determining soft information values associated with the minimum of the two difference metrics.

17. The receiver of claim 16 wherein the joint metric generator determines the first potential nondetected path metric and the second potential nondetected path metric by flipping desired detected symbols for current and previous states with border symbols and keeping interfering detected symbols.

18. The receiver of claim 16 wherein the joint metric generator determines the first potential nondetected path metric and the second potential nondetected path metric by flipping desired detected symbols for current and previous states with border symbols and permitting interfering detected symbols to float.

19. The receiver of claim 18 wherein the joint metric generator determines the first potential nondetected path metric and the second potential nondetected path metric by recalculating the nondetected path metrics by forcing the nondetected path metrics to come from a fixed symbols path.

20. The receiver of claim 16 wherein the joint metric generator determines the first potential nondetected path metric and the second potential nondetected path metric by flipping desired detected symbols for current and previous states with border symbols and farther symbols and permitting interfering detected symbols to float.

21. A mobile terminal for use in a mobile communications system comprising:

a receiver receiving co-channel differentially encoded signals; and

a joint demodulator receiving the co-channel differentially encoded signals and operable to determine jointly detected symbols and a corresponding detected joint metric, to determine a first potential nondetected metric, to determine a second potential nondetected metric, to calculate differences between the detected joint metric and the first and second potential nondetected metrics to produce two difference metrics, to determine a minimum of the two difference metrics, and to determine soft information values associated with the minimum of the two difference metrics.

22. The mobile terminal of claim 21 further comprising a decoder receiving the soft information values from the demodulator to decode the encoded signals.

23. The mobile terminal of claim 21 wherein the joint demodulator determines the first potential nondetected metric by flipping a current desired detected symbol and keeping a previous interfering detected symbol and determines the second potential nondetected metric by flipping a previous desired detected symbol and keeping a previous interfering detected symbol.

24. The mobile terminal of claim 23 wherein flipping a current desired detected symbol and flipping a previous desired detected symbol comprise selecting a closest desired nondetected symbol.

25. The mobile terminal of claim 21 wherein the joint demodulator determines the first potential nondetected metric and the second potential nondetected metric by flipping desired detected symbols for current and previous states with border symbols and keeping interfering detected symbols.

26. A base station for use in a mobile communications system comprising:

a receiver receiving co-channel differentially encoded signals; and

a joint demodulator receiving the co-channel differentially encoded signals and operable to determine jointly detected symbols and a corresponding detected joint metric, to determine a first potential nondetected metric, to determine a second potential nondetected metric, to calculate differences between the detected joint metric and the first and second potential nondetected metrics to produce two difference metrics, to determine a minimum of the two difference metrics, and to determine soft information values associated with the minimum of the two difference metrics.

27. The base station of claim 26 further comprising a decoder receiving the soft information values from the demodulator to decode the encoded signals.

28. The base station of claim 26 wherein the joint demodulator determines the first potential nondetected metric by flipping a current desired detected symbol and keeping a previous interfering detected symbol and determines the second potential nondetected metric by flipping a previous desired detected symbol and keeping a previous interfering detected symbol.

29. The base station of claim 28 wherein flipping a current desired detected symbol and flipping a previous desired detected symbol comprise selecting a closest desired nondetected symbol.

30. The base station of claim 26 wherein the joint demodulator determines the first potential nondetected metric and the second potential nondetected metric by flipping desired detected symbols for current and previous states with border symbols and keeping interfering detected symbols.

31. A mobile communications system generating soft information from co-channel differentially encoded received signals comprising:

a plurality of transmitters, each transmitting differentially encoded signals, one of the signals being a desired signal and the other signals being interfering signals; and

a receiver receiving co-channel differentially encoded signals, comprising the desired signal and the interfering signals, the receiver comprising a joint demodulator receiving the co-channel differentially encoded signals and operable to determine jointly detected symbols and a corresponding detected joint metric, to determine a first potential nondetected metric, to determine a second potential nondetected metric, to calculate differences between the detected joint metric and the first and second potential nondetected metrics to produce two difference metrics, to determine a minimum of the two difference metrics, and to determine soft information values associated with the minimum of the two difference metrics.

32. The mobile communications system of claim 31 wherein the joint demodulator determines the first potential nondetected metric by flipping a current desired detected symbol and keeping a previous interfering detected symbol and determines the second potential nondetected metric by flipping a previous desired detected symbol and keeping a previous interfering detected symbol.

33. The mobile communications system of claim 32 wherein flipping a current desired detected symbol and flipping a previous desired detected symbol comprise selecting a closest desired nondetected symbol.

34. The mobile communications system of claim 31 wherein the joint demodulator determines the first potential nondetected metric and the second potential nondetected metric by flipping desired detected symbols for current and previous states with border symbols and keeping interfering detected symbols.

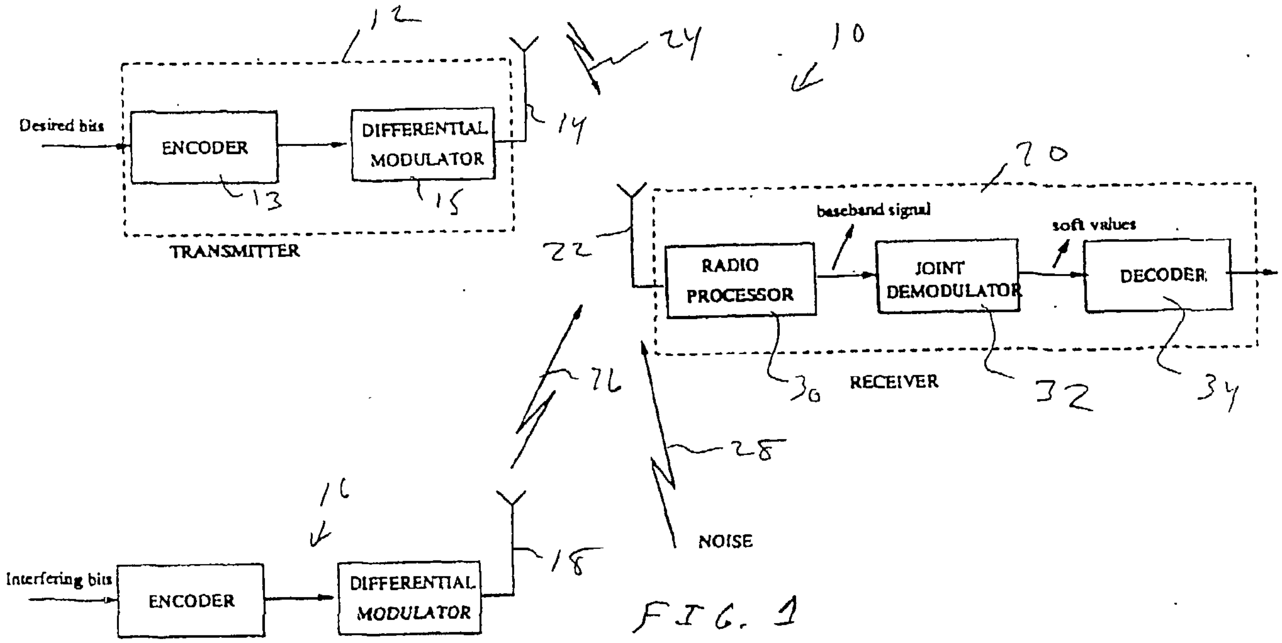

FIG. 1

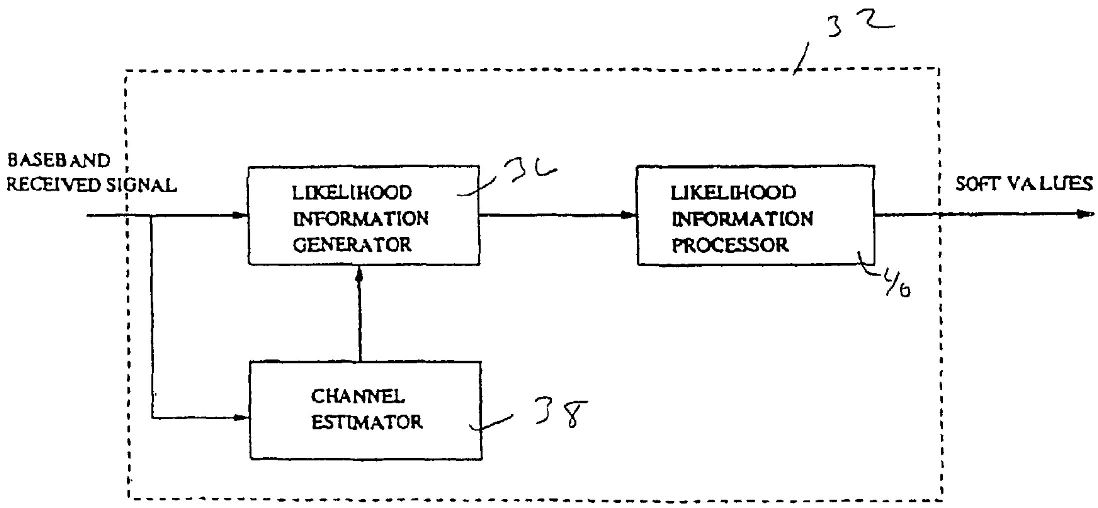

FIG. 2

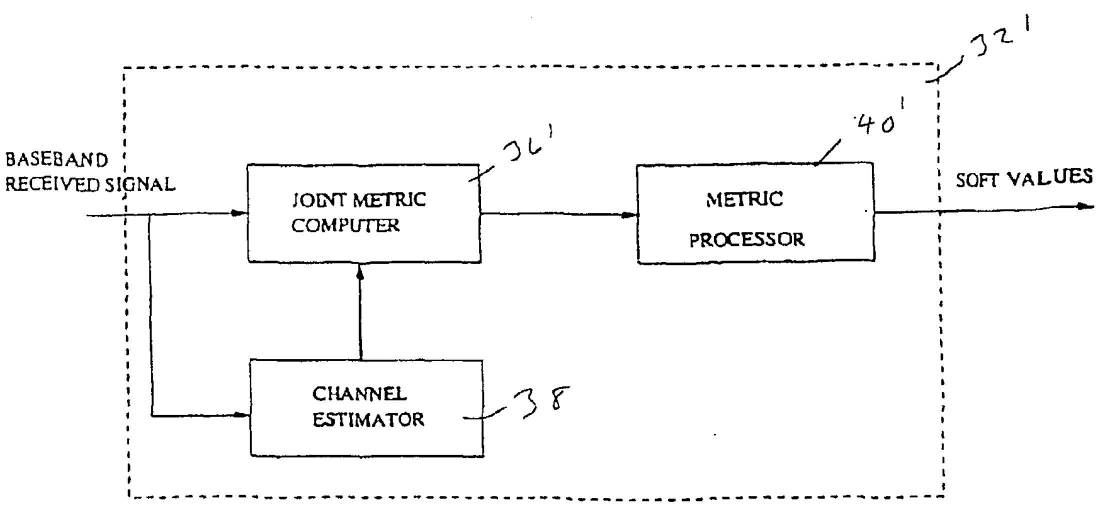

FIG. 3.

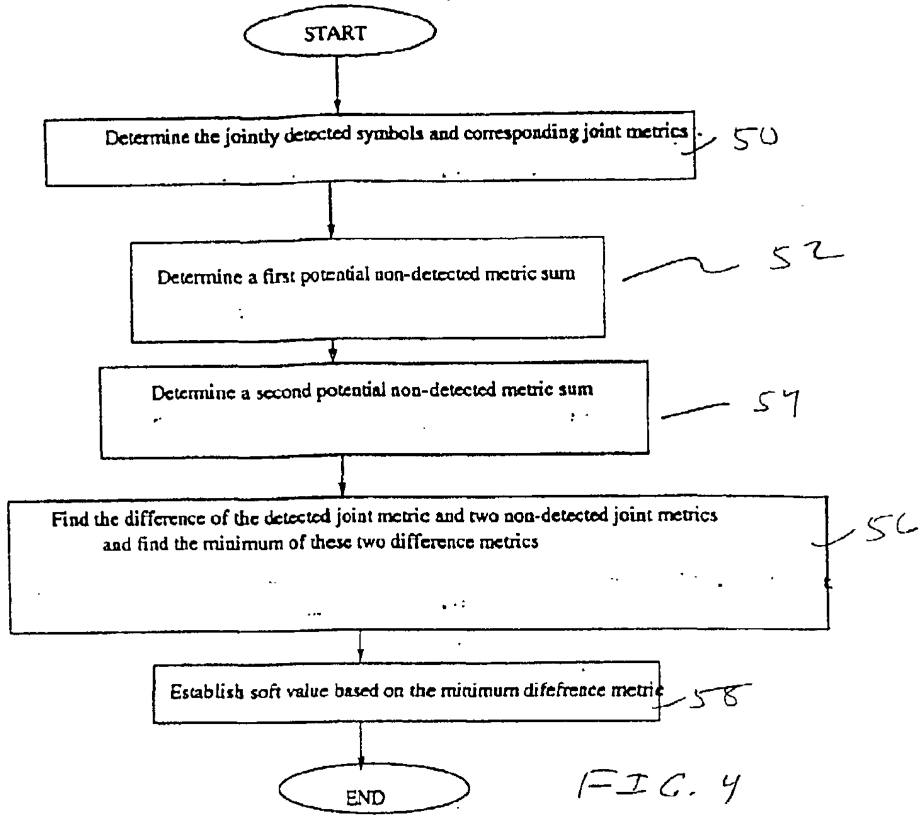
START
Determine the jointly detected symbols and corresponding joint metrics
50
Determine a first potential non-detected metric sum
52
Determine a second potential non-detected metric sum
54
Find the difference of the detected joint metric and two non-detected joint metrics and find the minimum of these two difference metrics
56
Establish soft value based on the minimum difefrence metric
58
END

FIG. 4

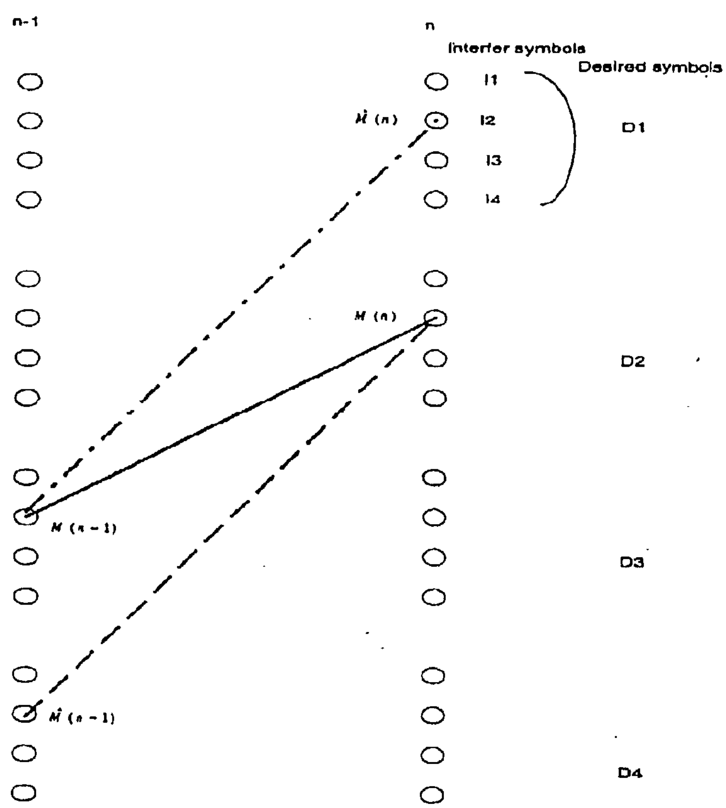
n-1
n
Interfer symbols
Desired symbols
I1
I2
I3
I4
D1
D2
D3
D4
$\hat{M}(n)$
$M(n)$
$M(n-1)$
$\hat{M}(n-1)$

FIG. 5